NATURAL ENEMIES OF *STEGOMYIA CALOPUS*, MEIGEN

BY

C. J. YOUNG

From the Laboratory of the Liverpool School of Tropical Medicine, Manáos

(*Received for publication* 25 *July*, 1921)

PLATES XIX AND XX

During the examination of various collections of water in Manáos for the larvae of *Stegomyia calopus*, their absence from many apparently suitable breeding-places attracted attention. Larvae were found capable of developing in water taken from some of these places, except when certain insects were present. A collection of various aquatic insects from ponds, igarapés, etc., was therefore made and placed in jars of water together with the larvae of *S. calopus*. Under these conditions the following were found to destroy *Stegomyia* larvae with varying degrees of efficiency: larvae of dragonflies, water bugs (*Hemiptera*) and their larvae, larvae of water beetles, and two others not identified. Of these the larvae of dragonflies and water bugs were found to be the most destructive to the larvae of *S. calopus* in captivity.

The habits of *S. calopus* larvae, which constantly range about in search of food, render them particularly liable to attack by predaceous insects, as compared to certain *Culex* and *Anopheles* larvae which may remain stationary at the surface for long periods. The commonest mosquito larvae found in Manáos were those of *Stegomyia calopus* and *Culex fatigans*; these two species were frequently discovered breeding together in wells, barrels and other collections of water. The movements of both larvae and pupae of *C. fatigans* differ from those of *S. calopus* in being much quicker, thus rendering them less easily caught by predaceous insects. The larvae of *C. fatigans* spend most of their time at the surface, but

descend occasionally. On the other hand, the larvae of *S. calopus*, although occasionally searching the surface film for food, while taking in air, spend most of their time ranging over the bottom and sides of their habitat and are thus particularly exposed to attack by the dragonfly larva, which lies in wait at various depths below the surface.

DRAGONFLY LARVAE

Dragonflies are present in Manáos throughout the year, there being no cold season, and larvae were readily found at all times. Although representatives of the AGRIONIDAE have been found in Manáos, members of the AESCHNIDAE and LIBELLULIDAE have been used exclusively in this work. Two species of each of these families are shown (Plate XX, figs. 4 to 7). The larvae of the LIBELLULIDAE (Plate XX, figs. 4 and 5) differ from those of the AESCHNIDAE (Plate XX, figs. 6 and 7) in having the abdomen shorter than the hind legs. According to Miall (1912), the larvae feed on insects, snails, tadpoles, and small fishes. In the laboratory they were observed to attack other aquatic insects, including members of their own species, water bugs and also tadpoles. I have never observed them attempt to seize any object which was not moving. Larvae have been observed resting on plants and on the sides and bottoms of artificial ponds and fountains, igarapés and other natural collections of water. They usually remain motionless and await the approach of suitable prey, which they seize by suddenly shooting out the labium. This is carried on a jointed arm which lies below the head and thorax when not extended. The victim is then broken up rapidly by the jaws and swallowed, only three or four seconds being required for disposal of a *Stegomyia* larva. When the moving object is out of range of the labium they sometimes spring towards it by squirting water from the rectum. When disturbed they also use this method of moving to a greater depth. Respiration is carried out by drawing water into the rectum, but the more fully developed larvae are said to be able to take in air through the thoracic spiracles and, in the case of Aeschnid larvae, directly into the rectum (Miall, 1912).

They are able to live in comparatively foul water. A dragonfly

deposited eggs in a barrel containing thick greenish water with traces of oil on the surface and sides of the barrel and decomposing vegetable matter at the bottom. Larvae of the type shown on Plate XX, fig. 5, developed and lived for at least thirty-nine days, by which time they had reached a size of 2 cms. in length. Observations could not be continued. No dragonfly larvae were found in water which did not receive rain.

One of the dragonfly larvae selected for experiment was identified as ***Pantala flavescens***, F., by Dr. G. A. K. Marshall, who describes it as a 'migratory and almost cosmopolitan species.' It was found in several of the artificial ponds and fountains in public squares in Manáos (Plate XIX, figs. 1 and 2), in the igarapés, and by Dr. R. M. Gordon in a broken drainpipe under the pavement of one of the public thoroughfares (Plate XX, fig. 3). In the pond shown (Plate XIX, fig. 1) they were constantly present along with various other species during the period of ten months that they were observed. They destroyed *S. calopus* larvae and pupae of all sizes, usually disposing of the larger ones first.

Six undetermined species of dragonfly larvae were also experimented with, all of which proved destructive to the larvae of *S. calopus*.

WATER BUGS, *HEMIPTERA*

The distribution of the water bugs (*Zaitha* spp.) used in the experiments is somewhat similar to that of the dragonfly larvae, the former having been found occasionally in the pond shown in Plate XIX, fig. 1, and in the igarapés. They are not, however, so plentiful, and difficulty was experienced in obtaining a supply at times. They fed on aquatic and other insects, such as grasshoppers, etc., when placed on the surface of the water, but only when living and showing movement. They also attack their own species. They suck the body juices of their victims, a specimen measuring 1·3 cms. in length taking anything from five to fifteen minutes to dispose of a fully grown *S. calopus* larva. The water bugs are thus considerably slower than the dragonfly larvae, but can continue feeding for a longer period. They usually rest on plants or sides of ponds with the posterior end of the body at the surface, the head downwards

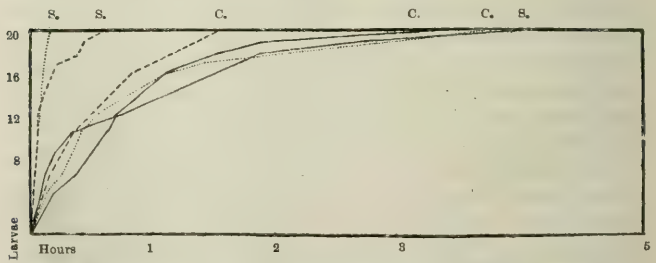
and the front pair of legs hanging free. When a suitable victim approaches it springs on it by a quick movement of the hind legs and seizes it with the fore legs which are adapted for clasping. When the captured insect is large all the legs may be used for gripping, and at least three mosquito larvae can be held at a time. Both adult and larval water bugs fed freely on Culicine larvae.

FEEDING EXPERIMENTS

Experiments were carried out to test the relative efficiency of dragonfly larvae and water bugs under artificial conditions.

Larvae of *P. flavescens*, measuring from 1·4 to 2·1 cms., and water bug larvae of 1·1 to 1·9 cms. in length, were used. Large cylindrical glass jars containing two litres of tapwater were employed, the depth of water in the jar being 10 cms. Twenty fully grown mosquito larvae were used in each experiment and were introduced before the insects to be tested, of which two were always employed. The temperature of the water varied between 28·5° and 32° C. The jar was observed continuously for the first half hour, and at three-quarter, one, one and a quarter, one and a half, two, two and a half, three and five hours, and the number of larvae destroyed during each period recorded. A control jar was used containing twenty mosquito larvae similar to those used in the experimental jar. Control larvae died in one experiment only, and this is not included below. In the graphs shown in text-figs. 1 and 2 the ordinals represent larvae destroyed and the abscissae time in hours. The curves in text-fig. 1 represent the averages of two

Fig. 1.

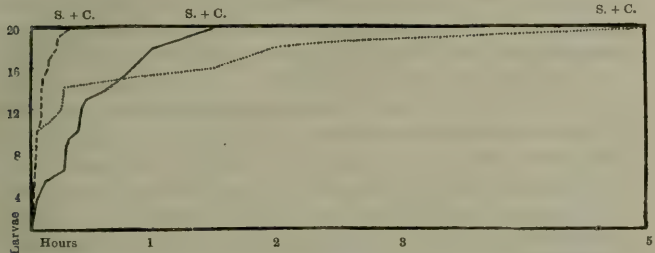


..... = 2 dragon fly larvae. —— = 2 water bug larvae. - - - - = 1 dragon fly + 1 water bug larva.

S. = 20 larvae of *S. calopus*. C. = 20 larvae of *C. fatigans*.

experiments in each case, but in fig. 2 each curve is constructed from one experiment. It will be observed in text-fig. 1 that fastest time was made by dragonfly larvae with *S. calopus* and second fastest by a combination of dragonfly, water bug and *Stegomyia* larvae. The other curves show only slight differences. In fig. 2 a mixture of

FIG. 2.



..... = 2 dragon fly larvae. —— = 2 water bug larvae. - - - - = 1 dragon fly + 1 water bug larva.

S. + C. = { 10 larvae of *S. Calopus*. / 10 larvae of *C. fatigans*.

equal numbers of *S. calopus* and *C. fatigans* larvae were used, and here a combination of dragonfly with water bug larvae was the most effective. In the dotted curve the two dragonfly larvae destroyed all the *S. calopus* in three minutes, but took five hours to the remaining *Culex* larvae.

So far as rate of destruction was concerned, therefore, under these artificial conditions, dragonfly larvae alone were the most effective with *S. calopus* larvae, and a combination of water bug and dragonfly larvae with those of *C. fatigans*.

As regards quantity, the largest number of fully grown *S. calopus* larvae destroyed by a larva of *P. flavescens* in twenty-four hours was one hundred and fifty-six. This larva during five days, being fed on the first, third and fifth days only, consumed three hundred and seventy-nine larvae. The largest number destroyed by a water bug was one hundred and six in twenty-four hours, but only half of these were killed for feeding purposes; a commoner figure is about sixty. When about to moult these insects cease feeding, so that the numbers consumed in twenty-four hours varied from 0 to the maxima mentioned.

Some experiments with dragonfly larvae were carried out under natural conditions.

An uncovered cement tank, measuring 1 metre square by 78 cms. deep, in a backyard was filled with water to within 10 cms. of the top. Between one thousand one hundred and one thousand two hundred mosquito larvae in all stages of development were introduced. The great majority of these were *S. calopus*, but a number of *C. fatigans* were also included. Pupae and eggs were also present. As a control, a glass jar was filled with water from the tank and a few of both species of larvae added.

At zero (five hours later) both species of larvae could be detected by a few moments inspection of the surface of the tank. Seven larvae of *P. flavescens*, varying in length from 2·3 to 1·3 cms., were then introduced.

At sixteen hours both species of larvae could be detected.

At twenty-four hours no *Stegomyia* larvae could be found after fifteen minutes search, but *Culex* larvae were still present.

At forty hours a few newly hatched *Stegomyia* and three *Culex* larvae only were found. One dragonfly larva was found dead.

At forty-eight hours no larvae of any kind were found.

At fifty hours the tank was emptied by syphoning out the water through several layers of gauze. No mosquito larvae were found.

In the control jar, which had been kept beside the tank throughout the experiment, the larvae remained alive and active. The temperature of the water in the tank varied between 29·5° and 33·5° C.

In the following experiment two barrels kept in an enclosure behind the laboratory were used. Although frequently receiving rain the water in these barrels was somewhat foul, particularly in one which had recently contained oil. In size they measured 85 cms. by 56 cms. at the widest part and the depth of water in each was 65 cms. *Stegomyia calopus* was breeding naturally in both, large numbers of pupae and larvae in all stages of development being present.

At zero (1 p.m.) five larve of *P. flavescens* were introduced into one barrel.

At eighteen hours only small larvae were present.

At twenty-four hours no larvae were found.

During this period larvae and pupae continued to be present in the control barrel to which the five dragonfly larvae were then transferred.

At three hours pupae and larvae were still present.

At seventeen hours only small larvae were present.

At twenty-four hours a few small larvae were present.

At forty-two hours no larvae were found.

Thus two barrels were cleared of *Stegomyia* larvae in twenty-four hours in one case, and in forty-two hours in the other, after the introduction of five dragonfly larvae.

The latter were allowed to remain in the last-mentioned barrel, which contained the larvae of various other insects. During the succeeding twenty-six days, five dragonflies hatched, no *Stegomyia* larvae were observed, but on three occasions newly hatched *Culex* larvae, which did not reach the pupal stage, were found. During the last nineteen days of this period *Stegomyia* and *Culex* larvae were present in the other barrel.

No *Stegomyia* larvae were found in Manáos in any water containing dragonfly larvae.

A certain artificial well which contained dragonfly larvae and was free from mosquito larvae, after being cleaned out was found to be breeding *Culex fatigans* and *Stegomyia calopus*, but no dragonfly larvae were discovered. Five weeks later *Stegomyia* larvae were absent and dragonfly larvae were again found. A few *Culex fatigans* larvae were also present.

THE DRAGONFLY AS AN ENEMY OF THE ADULT MOSQUITO

It was thought probable that the adult dragonfly would prey upon *Stegomyia calopus* if opportunity offered. In fine weather dragonflies are to be seen in the open places and larger streets of Manáos, and particularly around their breeding-places, as well as in the forest. During dull weather they are not so active, resting most of the time on the tops of shrubs and other objects, and rising only in pursuit of insects appearing close at hand.

Both the dragonfly and *Stegomyia calopus* are, therefore, active in Manáos in bright warm weather, but the mosquito is also active at

night. Except for a few attracted into houses by lights, dragonflies were not observed at night.

An attempt was made to see if they pursued *S. calopus* when given the opportunity. It was found possible by moving slowly to approach closely to the resting dragonfly without disturbing it, and *S. calopus* adults were then released from a glass tube at a distance of about a metre from it. The dragonfly nearly always pursued and caught the mosquito, usually returning to its perch consuming it. It was not always possible, owing to the rapidity of its flight, to observe whether the dragonfly actually caught the mosquito, but in most cases it was seen to occur. Five *S. calopus* were released one at a time near a resting dragonfly; four at least were caught, and probably all five. The dragonfly was then caught, and the contents of the alimentary canal teased up in saline and examined microscopically. The mosquitoes were found to be broken up into such small particles as to be unrecognisable, the only indication of *Stegomyia* being the large number of flat scales present.

Five different species of dragonfly, varying in length from 3 cms. to 6 cms., were tried against *S. calopus*, and all pursued and caught the mosquito. The larger ones were also observed to prey upon bluebottles and houseflies.

SUMMARY

Dragonflies and their larvae have been found to be destructive to *Stegomyia calopus* and their larvae respectively. Several other aquatic insects, including water bugs, have also been found to be inimical to *S. calopus* larvae.

My thanks are due to the Director of the Laboratory, Dr. Wolferstan Thomas, for assistance and advice, and to Miss A. M. Evans and Dr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, for identification of the insects mentioned.

REFERENCE

Miall, L. C. (1912). *The Natural History of Aquatic Insects*, Macmillan & Co.

EXPLANATION OF PLATE XIX

Fig. 1. Gardens in public square in Manáos. Habitat of larvae of *Pantala flavescens*, F., and other dragonflies and water bugs.

Fig. 2. Habitat of larvae of *Pantala flavescens*, F.

Fig. 1

Fig. 2